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(54) Title: DRY MICROPARTICULATED PROTEIN PRODUCT

(57) Abstract

The present invention provides a dry microparticulated protein product which may be used as a fat substitute when rehydrated.

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DRY MICROPARTICULATED PROTEIN PRODUCT

The present invention relates generally to a dry microparticulated protein product which is useful as a substitute for fat in food products, and more particularly to a spray dried, free-flowing microparticulated protein product which is readily rehydrated to give a fat substitute having desirable physical and organoleptic characteristics.

BACKGROUND

The consumption of fat-rich foods enjoys considerable popularity in and makes up a significant portion of the diets of many people. The undesirable nutritional impact related to the practice of consuming popular fat containing foods is widely recognized in the food industry and ways to reduce the fat content of food products are being developed to address the problems caused by consuming fat-rich foods.

One way to reduce the fat content of foods involves replacing the normal fat content of a food with a microparticulated protein product which has been described by Singer et al., U.S. Patents 4,734,287 and 4,961,953. The disclosure of both of these patents is incorporated by reference herein for the purpose of generally describing the desired physical and organoleptic characteristics of microparticulated protein. The microparticulated protein product described by Singer et al. is characterized as a macrocolloid of properly sized spheroidal protein particles formed by heating soluble proteins under high shear conditions. Controlled heat and shear processes are used to form an aqueous dispersion of denatured protein particles having a range of sizes providing organoleptic characteristics that closely mimic the

characteristics and properties of fat. This aqueous solution contains a mixture of protein microparticles, other solubilized proteins, sugars and starches as well as various salts, minerals and small amounts of insoluble materials.

Although the aqueous microparticulated protein product has been found to be an excellent substitute for the unwanted fat in a variety of food products (such as salad dressings, baked goods, coffee whitener, natural and processed cheeses, cream cheese, yogurt, puddings, soups, sauces, frostings, spreads, whipped toppings, ice cream and frozen desserts and related cultured dairy products) aqueous or liquid food ingredients typically have some undesirable attributes. For example, aqueous protein or other nutrient-containing ingredients are very susceptible to microbial contamination and extensive efforts may be needed to prevent undesired microbial contamination.

Similarly, aqueous proteinaceous products may have a shortened shelf-live unless proper precautions and measures are taken in packaging or storage. In addition, some food processors are simply better adapted to using dry product formulations and processes and cannot readily use liquid products. Other food processors may not be willing or able to deal with the special handling and storage requirements of liquid products.

Alternative methods may be used in the food industry to overcome some of the disadvantages associated with using liquid products. For example, aqueous whey protein solutions may be freeze-dried according to the procedures reported by Chang and Chang et al., U.S. Patents 4,029,825, 4,089,987, 4267,100 and 4,362,761 as well as by Concilion-Nolan et al., U.S.

Patent 4,058,510. In addition, different types of protein solutions may be dried using various spray drying processes. Specifically, spray dried protein products are reported in the following patents: Callewaert, U.S. Patent 4,486,345; Kajs, U.S. Patent 4,307,118; Cho, U.S. Patent 4,279,939; Cho et al., U.S. Patent 4,278,597; Davidson et al., U.S. Patent 4,172,828 and Gomi et al., U.S. Patent 4,113,716. Furthermore, spray dried, treated or modified whey protein products are reported in the following documents: Poole et al., U.S. Patent 4,572,837; May et al., U.S. Patent 4,183,970; Kuipers, U.S. Patent 3,930,039; U.K. Patent application 2,063,273; European Patent application 0 347 237 and the Netherlands Patent application 806237.

All of the above documents report products having a variety of functional properties when formulated or used in food products. None of the documents, however, describe the microstructure of the dried product or describe a product that may rehydrate without loss of desirable characteristics after being spray dried. Furthermore, there are reports that drying processes adversely affect desirable physical characteristics of protein solutions. See, e.g., Jelen et al., Milchwissenshaft, 34, 351-356 (1979) reporting that both water-holding capacity and microstructure of heated whey protein powders are detrimentally affected by spray-, freeze-, and roller-drying processes.

A need in the food industry exists for an acceptable fat substitute in a dry form that is stable, has a long shelf-life and is readily adapted for use with existing food formulations and processing equipment. Optimally, such a fat substitute would be a microparticulated protein product that is an easy-to-

handle, free-flowing powder that readily rehydrates without any appreciable loss of the desired organoleptic characteristics.

BRIEF SUMMARY

The present invention provides a spray dried microparticulated protein product characterized as an agglomerate of rehydratable proteinaceous microparticles surrounded by a soluble matrix.

According to one aspect of the invention, a dry, free-flowing protein product of this invention includes a spheroidal agglomerate of a soluble proteinaceous matrix and microparticulated protein. When the agglomerate is hydrated, substantially nonaggregated, spheroidal particles of denatured protein having substantially smooth, emulsion-like organoleptic character are obtained. Preferably, the nonaggregated spheroidal particles of denatured protein have a mean diameter greater than about 0.1 micron and less than about 3 microns.

A dry, agglomerated microparticulated protein product of this invention is preferably derived from undenatured substantially soluble protein. Suitable proteins include proteins derived from the group consisting of whey, bovine serum albumin, egg white albumin, soy and mixtures thereof. A highly preferred protein is derived from whey.

Suitable processes for drying a microparticulated protein product include employing conventional spray drying techniques with a solution of denatured protein microparticles formed by heat and high shear. A preferred microparticulated protein solution which is well suited to being spray dried is described in U.S. patent application Ser. No.

07/524,598 filed May 17, 1990. The disclosure of that application is incorporated by reference herein for the purpose of describing preferred processes and apparatus useful for the preparation of microparticulated protein solutions.

The dry microparticulated protein product of the invention may be used to provide a variety of food products prepared from formulations providing replacement of part or all of the fat content of the food. Thus, a variety of food products having part or all of the fat content of the food replaced with a hydrated agglomerate of this invention are also considered to be within the scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a photomicrograph of a liquid microparticulated protein product.

Figure 2 is a photomicrograph (environmental SEM) of a spray dried microparticulated protein product.

Figure 3 is a photomicrograph of a rehydrated spray dried microparticulated protein product.

DETAILED DESCRIPTION

The present invention provides microparticulated protein as an agglomerated, free-flowing powder which readily rehydrates without loss of desired physical or organoleptic characteristics. The dried powder is characterized as an essentially spheroidal agglomerate of protein microparticles that are reversibly held in a soluble or solubilizable matrix. When the agglomerated microparticles are rehydrated, the matrix readily dissolves or disperses

and provides a suspension of nonaggregated microparticles useful as a fat substitute. Microscopic examination of the rehydrated protein microparticles indicates that the spray drying process has no apparent irreversible effect on the microstructurre of the microparticles. Both the physical and organoleptic characteristics of the rehydrated microparticles are substantially identical to microparticles that have not been dried. A comparison of Figures 1 and 3 indicates that the microparticles of the rehydrated dried product are substantially identical to the microparticles before spray drying.

In addition, the dried product has an extended shelf-live compared to the liquid product. The dried product is stable for at least fourteen weeks when stored at room temperature. When the water activity level is less than about 0.4, and preferably less than about 0.3, no flavor deterioration or clumping of the powder is evident.

The following examples are provided to further describe the present invention but should not be construed as limiting in scope. Example 1 describes a preferred process for producing a liquid solution of protein microparticles. Example 2 describes a process of drying such a solution of protein microparticles.

Example 1

Microparticulated Whey Protein

A sweet whey protein solution is subjected to both ultrafiltration and low heat evaporation to provide a liquid whey protein concentrate which has a mild cooked flavor and a minimum protein solubility of 93%. A suitable liquid whey protein concentrate is WPC-54 whey protein concentrate which is available from

First District Association, Litchfield, Minnesota. The characteristics of this whey protein concentrate are listed in Table 1.

Within 48 hours after evaporative concentration, the liquid whey protein concentrate is deaerated in a VERSATOR deaerater (Cornell Machine Company, Springfield, New Jersey) and bottom fed into a sanitary tank equipped for non-aerating agitation.

Table 1

Whey Protein Concentrate

Total Solids	43 ± 2%
Protein	23 ± 1.7 %
Fat	< 1.94%
Lactose	13.8 ± 1.2 %
Ash	< 3 %
pH	6.0 - 6.4

(All % on a wet basis)

The deaerted concentrate is then pumped at a rate of 1200 lbs/hr by a positive displacement pump through an in-line strainer (300 micron cheesecloth), a mass flow meter and plate heat exchanger which raises the temperature of the concentrate to about 145-150 °F.

The heated concentrate is then pumped through a recirculating holding tube at a flow rate of approximately 15 ft/sec or at a flow rate sufficiently high enough to prevent fouling of the holding tube.

As the concentrate is recirculated through the holding tube, the temperature is increased to about 155 °F due to the energy supplied by the pump. The average residence time of the concentrate in the recirculating holding tube is approximately six minutes.

The concentrate is then sent from the recirculating holding tube into a plate surface heat exchanger which cools the concentrate to a temperature of about 150 °F, a temperature lower than the target peak temperature inside a heat and high shear generating ("MicroCooker") apparatus.

The cooled concentrate flows from the recirculating holding tube and heat exchanger into a microcooker apparatus which is described in U.S. Patent 4,828,396 with the exception that the inlet and outlet ports have been interconverted, i.e., the inlet port is disposed where the outlet port is shown in Figures 1 and 2 of U.S. Patent 4,828,396 and the outlet port is located at the bottom of the bowl shaped vessel. The temperature of the concentrate in the microcooker apparatus is raised to 200 °F within about 5 seconds under high shear conditions. Rigorous control of the concentrate temperature is maintained in the microcooker apparatus at 200 °F by a cascade control loop. The cascade control loop monitors the temperature of the microparticulated product exiting the microcooker apparatus and holds the temperature constant by regulating the temperature of the mixture leaving the plate surface heat exchanger downstream from the recirculating holding tube.

The speed of the rotor in the microcooker apparatus is held constant at about 6000 rpm. At this rpm, the shear rate is about 46,000 reciprocal seconds at the tips of the rotor which has a diameter of approximately 7 inches.

After exiting the microcooker apparatus, the product flows directly into an recirculating product cooling loop and is pumped through a plate heat exchanger at a rate of about 6,000 lbs/hr in order to

lower the temperature of the concentrate to less than about 100 °F. The cooled product is removed from the product cooling loop at an outlet when the final product is at a temperature of less than 45 °F.

Control of the final microparticulated product viscosity may be achieved by varying the temperature of the concentrate in the recirculating holding tube loop. A reduction in the concentrate temperature in the holding tube decreases the viscosity of the final product. A preferred viscosity range for the final product is about 2400-3300 cps (Brookfield, 5 °C, 50 rpm, spindle #27).

The cooled, microparticulated liquid product is finally sent to a gently agitated blend tank or, if desired, to an on-line filler.

According to the above process, a whey protein concentrate having the characteristics listed in Table 2 was processed using the processing parameters listed in Table 3 to give a final product having the characteristics listed in Table 4.

Table 2

Whey Protein Concentrate

Total Solids	43.49%
Protein	23.49 %
Fat	1.86 %
pH	6.22

Table 3

Processing Parameters

Flow Rate	1200 lbs/hr
Holding Tube Temperature	147-157 °F
Viscosity of Product at Outlet	2340-3960 cps (Brookfield, 5 °C, 50 rpm, spindle #27)

Microcooker rotor speed	6000 rpm
Temperature of Product at Outlet	38-43 °F

Table 4

Liquid Product

Total Solids	42.15 %
Protein	22.81 %
Fat	1.80 %
Microparticulated Protein	12.5 %
Volume Weighted Median Microparticulated Protein Diameter	1.17 microns (no oversized particles > 3 microns, Horiba Particle Size Distribution Analyzer, CAPA-700, Irvine, CA)
pH	6.35
Viscosity	3920 cps (Brookfield, 5 °C, 50 rpm, spindle #27.)

Example 2

Spray Dried Protein Product

A spray dried protein product was prepared from the liquid product having the characteristics listed in Table 4 of Example 1. The liquid microparticulated product is added to a refrigerated feed tank (temperature < 45 °F) and the product is pumped from the feed tank through a recirculating shell and tube heat exchanger to provide a temperature of about 120-130 °F. The recirculation flow rate must be sufficiently high enough to prevent fouling of the heat exchanger.

The heated product is supplied to a high pressure pump which feeds the spray drying apparatus. The pressure of the product leaving the pump is typically about 3500-4000 psi when the product is sprayed through nozzle such as a SPRAY SYSTEMS 7A (50/28) Nozzle (orifice/insert) (Spraying Systems Company, Wheaton, IL).

The pumped product is then fed into a NIRO bustled dryer (Hudson, WI) having a three nozzle product inlet at a flow rate of about 4,000 - 5,500 lbs/hr.

During the drying process, the spray dryer is fed with concurrent, heated, filtered air at a temperature of about 400-450 °F (depending on the ambient humidity) which provides an air outlet stream temperature of approximately 180-210 °F.

The dried microparticulated product is conveyed from the drier using filtered, dry air at about room temperature. Contact with the conveying air rapidly cools the dried microparticulated product to ambient temperatures. The cooled, dried product is collected from primary and secondary cyclones, passed through a sifter screen, and collected in powder collection silos. The final moisture content of the dried product is between about 3-4 wt. %. The final moisture content is conventional controlled by adjusting the air outlet temperature which in turn establishes the air inlet temperature and drying time.

A dried microparticulated protein prepared according to the above process has the characteristics listed in Table 5.

Table 5

Dried Microparticulated Protein

Appearance	Free-flowing, white to cream colored powder
Microparticulated Protein	> 50 wt. %
Powder Size	98% pass through a 40 mesh screen
Moisture Content	< 4 wt. % (vacuum oven, 165 °F, 16 hour)
Flowing Density	0.3 - 0.5 g/cm^3
Volume Weighted Median Microparticulated Protein Diameter after Rehydration	1.2 ± 0.3 microns (Horiba Particle Size Distribution Analyzer, CAPA-700, Irvine, CA)

Numerous modifications and variations in practice of the invention are expected to occur to those skilled in the art upon consideration of the foregoing description of preferred embodiments thereof. Consequently, only such limitations should be placed upon the scope of the invention as appear in the appended claims.

WHAT IS CLAIMED IS:

1. A dry microparticulated protein product comprising:

a spheroidal agglomerate of microparticulated protein capable of rehydrating to provide substantially nonaggregated, spheroidal particles of denatured protein.

2. A dry microparticulated protein product of claim 1 wherein the nonaggregated spheroidal particles of denatured protein have a mean diameter greater than about 0.1 micron.

3. A dry microparticulated protein product of claim 1 wherein the nonaggregated spheroidal particles of denatured protein have a mean diameter less than about 3 microns.

4. A dry microparticulated protein product of claim 1 wherein the protein is derived from undenatured substantially soluble protein.

5. A dry microparticulated protein product of claim 1 wherein the protein is derived from the group consisting of whey, bovine serum albumin, egg white albumin, soy and mixtures thereof.

6. A dry microparticulated protein product of claim 1 wherein the protein is derived from whey.

7. A dry microparticulated protein product of claim 6 wherein the whey protein particles have a mean diameter greater than about 0.1 micron.

8. An aqueous dispersion of microparticulated protein prepared by rehydrating the dry microparticulated protein product of claim 1.

9. A dry, free-flowing protein product comprising:
a spheroidal agglomerate of a soluble proteinaceous matrix and microparticulated protein wherein the agglomerate is hydratable to provide substantially nonaggregated, spheroidal particles of denatured protein having substantially smooth, emulsion-like organoleptic character when hydrated.

10. A dry protein product of claim 9 wherein the nonaggregated spheroidal particles of denatured protein have a mean diameter greater than about 0.1 micron.

11. A dry protein product of claim 9 wherein the nonaggregated spheroidal particles of denatured protein have a mean diameter less than about 3 microns.

12. A dry protein product of claim 9 wherein the protein is derived from undenatured substantially soluble protein.

13. A dry protein product of claim 9 wherein the protein is derived from the group consisting of

whey, bovine serum albumin, egg white albumin, soy and mixtures thereof.

14. A dry protein product of claim 9 wherein the protein is derived from whey.

15. A dry protein product of claim 14 wherein the whey protein particles have a mean diameter greater than about 0.1 micron.

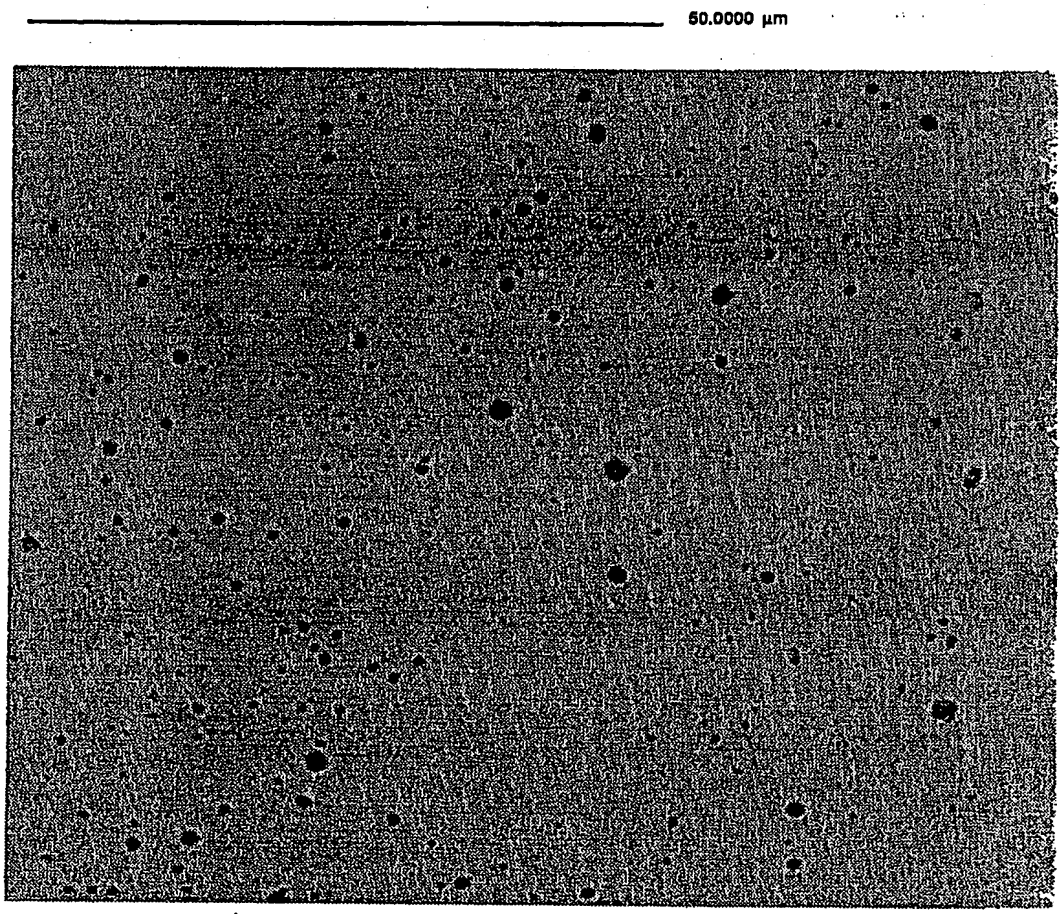

FIG. 1

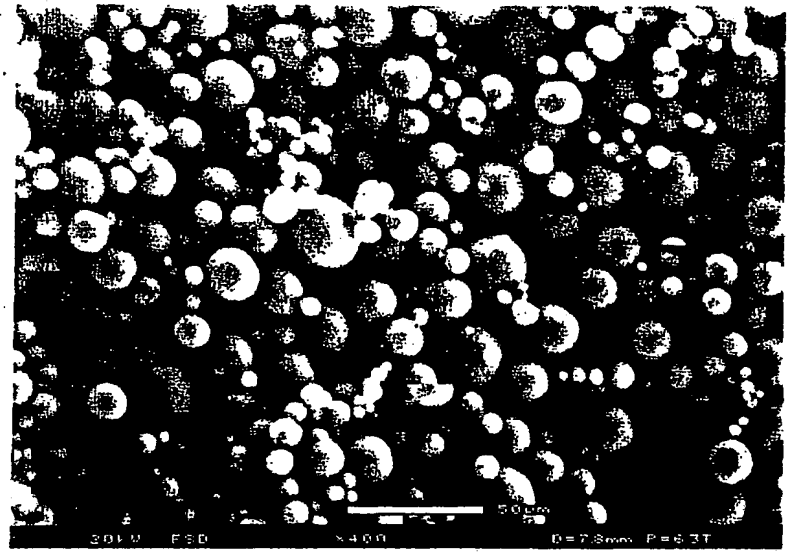

FIG. 2

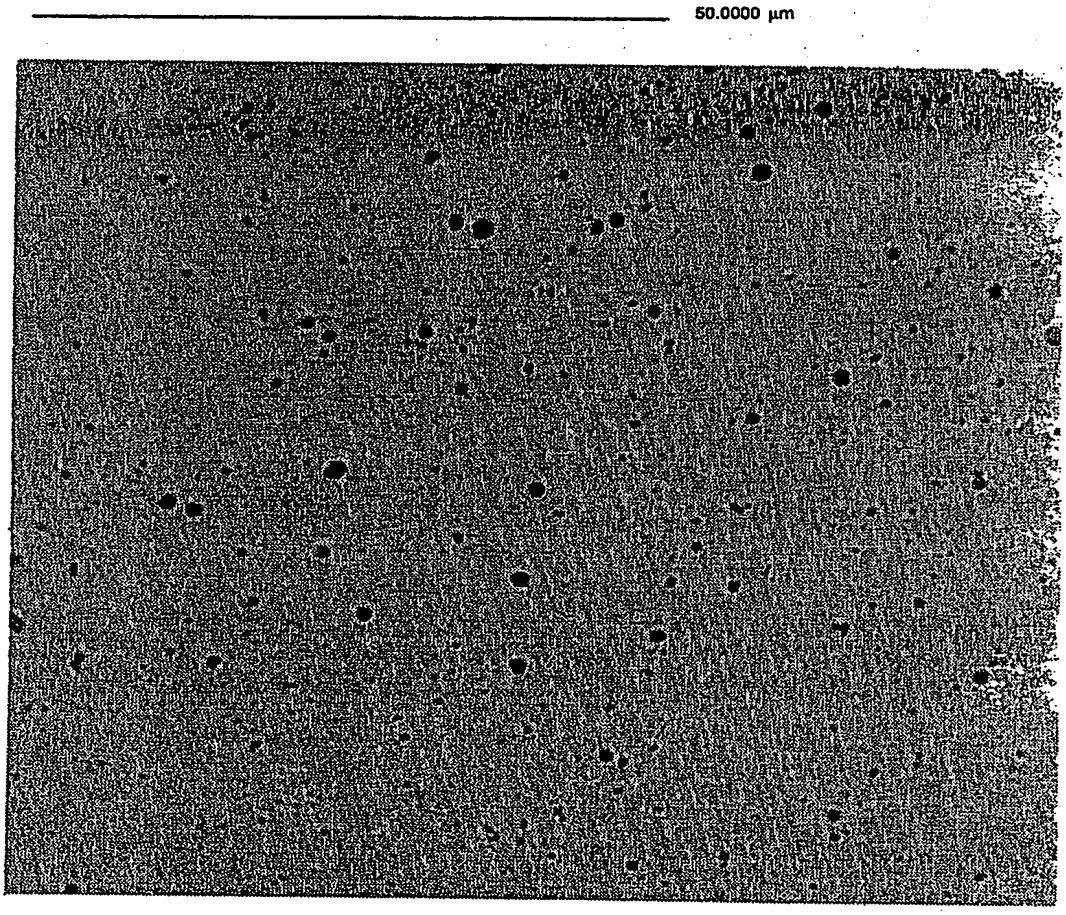

FIG. 3

INTERNATIONAL SEARCH REPORT

PCT/US92/09180

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :A23J 1/20

US CL :426/583, 656, 804

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 426/583, 656, 804

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,734,287 (SINGER ET AL) 29 MARCH 1988; See the Abstract	1-15
Y	US, A, 5,021,248 (STARK ET AL) 04 JUNE 1991 See claim 1, 3 and 6, col. 3, lines 13-15 and col. 9, lines 15-30.	1-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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